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(54) Device for measurement of angular velocity of a rotating body

(57) A device for measurement of angular velocity of a rotating body comprises a transducer (1) composed of a core (2), an exciting winding (4) and a measuring winding (3). Said transducer (1) is arranged at the periphery of a toothed disc (10) co-rotating with the rotating body. The current flowing through the exciting winding (4) and thus the intensity of the magnetic field in the air gap between the transducer (1) and the toothed disc (10) is controlled in dependence upon the magnitude of the voltage induced in the winding (3) in such a fashion that, in the event of a standstill or a low angular velocity, maximum current flows, which current reduces when the angular velocity increases. In this way the induced signal strength is rendered less variable. An evaluation circuit is also connected to winding (3), the frequency of the signal voltage being a measure of the speed of disc (10). The arrangement may be used for measuring wheel speed in an anti-lock braking system.

Fig. 1

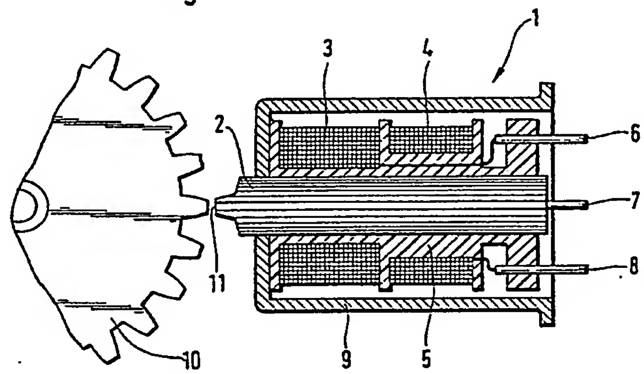

Fig. 2

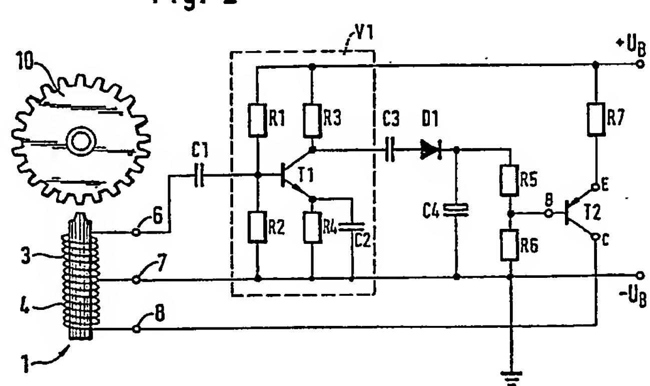

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Fig. 1

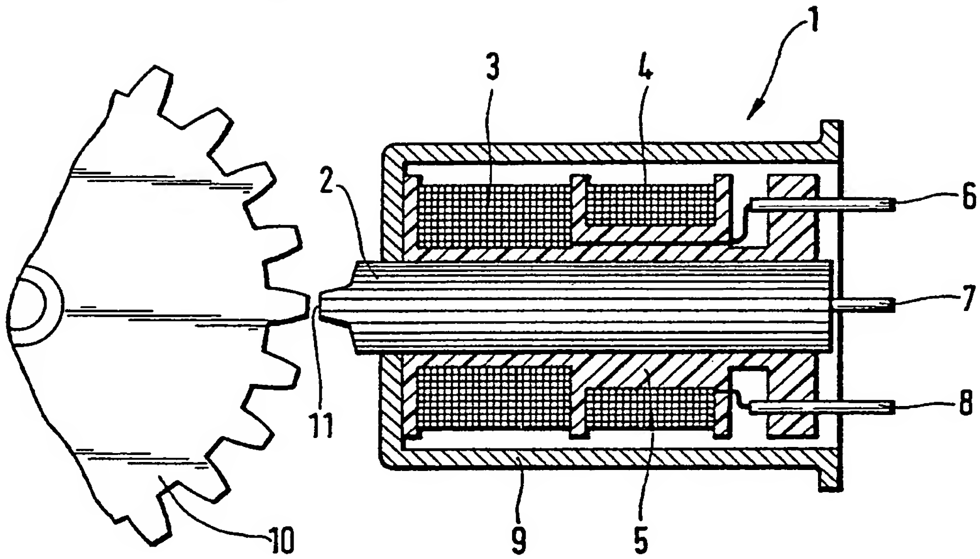
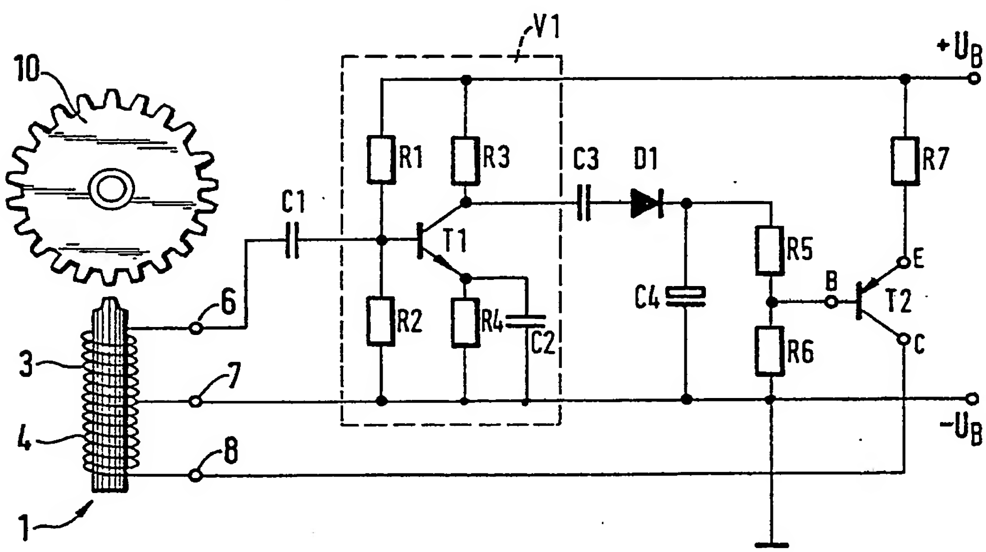


Fig. 2



SPECIFICATION

Device for measurement of angular velocity of a rotating body

This invention relates to a device for measurement of angular velocity of a rotating body, i.e. a wheel, a shaft or the like, and for the generation of an alternating signal whose frequency is proportional to the angular velocity, including a measuring data emitter in the form of a toothed disc, and a stationary, inductive transducer arranged at the periphery of the toothed disc and separated from the toothed disc by an air gap, which transducer creates a magnetic field penetrating the air gap.

Devices with transducers, i.e. sensors of this kind are, for instance, used for the measurement of the rotational behaviour of wheels in electronically controlled anti-wheel-lock brake systems. Within a controller of such brake systems, the sensor signals are logically combined and processed by means of wired or programme-controlled electronic switching circuits. In this manner, control signals are generated which are, for instance, transmitted to electromagnetically actuated hydraulic multi-directional control valves, and thus lead to the desired brake pressure modulation and finally to wheel slip control.

Inductive transducers of this kind are known in a great many forms. In West German printed and published patent specification 20 19 01 a sensor is described which comprises a permanent mangnet, and which is also arranged at the periphery of a toothed disc serving as a measuring data emitter and co-rotating with the rotating body. Between the pole shoes of the magnet and the toothed disc, there is a small air gap wherein a magnetic field generated by the permanent magnet is formed. Due to the passing from tooth to tooth gap, the magnetic field is changed during the rotation of the toothed disc and induces an alternating signal in a measuring coil wound around the core of the permanent magnet, the frequency of said alternating signal being proportional to the rotational movement of the toothed disc. The amplitude of the measured signal also increases almost linearly with the rotational movement. This is disadvantageous in that at slow revolutions, a measured signal having only a very low amplitude is available, which measured signal can only be separated from the inevitable unwanted signals using a great deal of electronic equipment. In addition, it cannot be avoided that during standstill of the wheel, the toothed disc is magnetized by means of the permanent magnet field, which also results in unwanted signals during operation. Finally, the functioning of this known sensor and/or measuring device is, in addition, impaired by means of ferrous particles which may accumulate at the poles under the influence of the permanent magnet field and may lead to short-circuit bridges.

Devices for the measurement of velocities and/or transducers of a similar type ar , e.g., also illustrated and described in West German printed and published patent specification 21 13 307 and West German printed and published patent application 34 00 870.

The present invention has an object to overcome the above-mentioned disadvantages of known sensors and to develop a device for the measurement of the angular velocity of a rotating body which device supplies, over the whole working range, in particular even at low angular velocities, a measured signal or wanted signal which can be separated from unwanted signals and which can be evaluated by means of comparatively little electronic equipment. A high operational reliability even over longer periods of time is, in addition, required.

According to the present invention there is provided a device for measurement of angular velocity of a rotating body, and for the generation of an alternating signal whose frequency is proportional to the angular velocity, including a measuring data emitter in the form of a toothed disc, and a stationary, inductive transducer arranged at the periphery of the toothed disc and separated from the toothed disc by an air gap, which transducer creates a magnetic field penetrating the air gap, characterised in that the magnetic field is created by means of an exciting winding wound around a coil core, through which exciting winding a controlled direct current flows when the measuring device is in operation, and in that a second winding, namely a measuring winding, is provided wherein an output signal of the transducer representing a measured signal can be induced in the event of a change of the magnetic field as a result of a rotational movement of the toothed disc.

A controlled magnetic field is thus generated in the air gap between the toothed disc and the transducer instead of a permanent magnet field. When the electrical power supply is switched off, which condition prevails in an automotive vehicle when the ignition has been switched off, the magnetic field is reduced to zero so that iron particles or rubbed-off parts accumulated within the area of the air gap at the pole or at the pole shoes can fall off and can thus no longer lead to malfunctions. By means of the control of the exciting current it is, in addition, achieved that a high magnetic field is generated even at low velocities, said magnetic field creating during this phase of operation a measured signal having a comparatively high amplitude. When the velocity is increased, however, the controlled exciting current decreases, the load on the battery thus being reduced and a constant or only slightly increasing measured signal amplitude being achieved. The evaluability of the measured signal is thus improved considerably, and the electronic equipment required for this purpose is reduced.

According to a favourable embodiment of the present invention, the transducer is equipped with an electronic closed-loop control circuit for producing the controlled direct current for the exciting winding.

The amount of the direct current flowing through the exciting winding is, expediently, controllable in depenence upon the magnitude of the measured signal of the transducer following rectification thereof. In many cases it is favourable if the magnitude of the controlled direct current is variable

at least approximately inversely proportional to the magnitude of the rectified measuring signal.

Both windings, namely the exciting winding and the measuring winding, can be wound around a common coil core which includes an end face and/or pole face directed towards the toothed disc, said face in part defining the air gap between the toothed disc and the transducer, which air gap is penetrated by the magnetic field.

The closed-loop control circuit may comprise a variable resistance, e.g. a transistor, through the intermediary of which the exciting winding is connected to a direct voltage or direct current source, which resistance can be varied at least approximately proportional to the magnitude of the rectified measured signal. Between the control connection of the variable resistance – this is, in the aforementioned special case, the base of the transistor – and the output of the measuring winding, an amplifier stage with a rectifier arranged downstream thereof, e.g. a half-wave rectifier, is expediently provided.

An embodiment of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 illustrates a sectional view of a transducer according to the invention and its arrangement relative to a toothed disc; and

Figure 2 shows a particularly simple embodiment of a closed-loop control circuit intended to influence the exciting current of the transducer.

As shown in Figure 1, the transducer 1 of the measuring device according to the present invention comprises substantially a core 2 and two coils or windings 3, 4, namely an exciting winding and a measuring winding. Both coils are wound around a coil carrier 5. The winding terminals are referred to as 6, 7 and 8. The core 2 normally consists of ferromagnetic material. The whole arrangement is located in a housing 9 protecting said arrangement against mechanical influences and humidity.

The transducer 1 is, for instance, fixed to a vehicle axle (not shown), whereas a toothed disc 10 in the form of a measuring data emitter co-rotates with a wheel, shaft or another rotating body (not shown) the angular velocity of which is to be measured.

The core 2 of the transducer 1 extends from its end or pole face 11 directed towards the toothed disc 10 into the housing, and is shaped such that a magnetic field having a relatively high density is created in the air gap between the toothed disc 10, the measuring data emitter, and the pole or end face 11 of the transducer 1, so that during operation, when the disc 10 is rotating, the magnetic flux changes so strongly during the transition from one tooth to a tooth gap that even in the event of a low angular velocity, as a consequence of this change in flux, a sufficient measuring voltage is induced in the measuring winding. In this case, the frequency of the measured voltage is directly proportional to the angular velocity and to the number of te th of the toothed disc 10. At a constant exciting current, the magnitude of the measured voltage would increase and decrease proportionally to the angular velocity.

A closed-loop control circuit of the device according to the invention is illustrated in Figure 2. In this case, an exciting current, namely a controlled direct current derived from a vehicle battery U_B here serving as a voltage source, flows via the terminals 7 and 8. The magnitude of this exciting current is controlled in dependence upon the measured signal picked up by the terminals 6 and 7 of the measuring winding by means of a controllable variable resistance, here a transistor T2. For this purpose, an amplifier stage V1 comprising in this case, substantially, a transistor T1, a voltage divider R1, R2 as well as collector and emitter resistances R3, R4, with a half-wave rectifier D1, C4 arranged downstream of said amplifier stage, is connected to the terminals 6 and 7 of the measuring winding through the intermediary of a coupling capacitor C1. The transistor T2 which serves as a variable resistance and which determines the amount of the exciting current is actuated via a voltage divider R5, R6 at the outlet of the half-wave rectifier D1, C4. "B" designates the base, "E" the emitter and "C" the collector of the transistor T2.

An evaluation circuit wherein the frequency of the measured signal and thus the information about the rotational behaviour of the wheel is evaluated is, in addition, connected to the terminals 6, 7 of the measuring winding 3 via signalling lines (not shown).

The closed-loop control circuit depicted in Figure 2 operates as follows:

As long as the wheel whose angular velocity is to be measured, and thus the toothed disc 10, stands still or only rotates at a low velocity, the voltage at the output of the half-wave rectifier and/or across the voltage divider R5, R6 is minimal. After switching the ignition and thus the supply voltage U_B on, the transistor T2 is, therefore, switched so as to be open through the intermediary of the base resistance R6. During this phase, the maximum possible exciting current which is, substantially, only limited by means of the emitter resistance R7 and the internal resistance of the exciting winding 4 flows via the transistor T2 and via the winding 4.

At first, the transistor T1 of the amplifier stage is also switched so as to be open through the intermediary of the base resistance R1. However, as soon as the amplitude of the measured signal, namely the alternating voltage between the terminals 6 and 7, increases due to higher angular velocities of the toothed disc 10, the capacitor C4 at the output of the amplifier stage V1 is charged during the blocking phase of the transistor T1 via the collector resistance R3, capacitor C3 and the diode D1. A voltage drop which leads to an increase in the potential at the base B of the transistor T2 and thus to a reduction of the exciting current flowing via the transistor T2 is generated across the capacitor C4 and thus across the voltage divider R5, R6. This results, on the other hand, in a reduction of the magnetic field between the core 2 and the toothed disc 10 and thus of the voltage induced in the measuring winding 3 when the angular velocity of the disc 10 remains constant. By means of this "counter coupling", the amplitude of the measured signal at the output of the measuring winding 3

becomes (almost) independent of the angular velocity; in any case, the amplitude variation is less significant as compared with transducers with a constant magnetic field. In this manner, the evaluability of the measured signal, in particular the separation between unwanted and wanted signal, is improved considerably.

The depicted closed-loop control circuit represents one of many possibilities. When designing the control circuit, attention must be paid, above all, to the fact that the exciting current reaches, in the manner described above, a maximum, after the ignition has been switched on, in the event of a standstill of the wheel or a low angular velocity and is reduced to a minimum value at an increasing measured signal or wanted signal in a manner depending on the respective case of application.

CLAIMS

1. A device for measurement of angular velocity of a rotating body, and for the generation of an alternating signal whose frequency is proportional to the angular velocity, including a measuring data emitter in the form of a toothed disc, and a stationary, inductive transducer arranged at the periphery of the toothed disc and separated from the toothed disc by an air gap, which transducer creates a magnetic field penetrating the air gap, characterised in that the magnetic field is created by means of an exciting winding (4) wound around a coil core (2), through which exciting winding a controlled direct current flows when the measuring device is in operation, and in that a second winding (3), namely a measuring winding, is provided wherein an output signal of the transducer (1) representing a measured signal can be induced in the event of a change of the magnetic field as a result of a rotational movement of the toothed disc (10).

2. A device according to claim 1, characterised in that the transducer (1) is equipped with an electronic closed-loop control circuit for producing the controlled direct current for the exciting winding (4).

3. A device according to claim 1 or claim 2, characterised in that the magnitude of the direct current flowing through the exciting winding (4) is controllable in dependence upon the magnitude of the measured signal of the transducer (1) following rectification thereof.

4. A device according to claim 3, characterised in that the magnitude of the direct current flowing through the exciting winding (4) is variable at least approximately inversely proportional to the magnitude of the rectified measured signal.

5. A device according to any one of the preceding claims, characterised in that the exciting and the measuring winding (4, 3) are both wound around the coil core (2) which includes an end face and/or pole face (11) directed towards the toothed disc (10), said face in part defining the air gap between the toothed disc (10) and the transducer (1), which air gap is penetrated by the magnetic field.

6. A device according to claim 3 as appendent to claim 2, characterised in that the closed-loop control circuit comprises a variable resistance (T2) through the intermediary of which the exciting winding (4) is connected to a direct voltage or direct current source (U_B), which resistance can be varied at least approximately proportional to the magnitude of the rectified measured signal.

7. A device according to claim 6, characterised in that a transistor actuated by the rectified measured signal is provided as variable resistance (T2).

8. A device according to claim 6 or claim 7, characterised in that an amplifier stage (V1) with a rectifier (D1, C4) arranged downstream thereof is provided between a control connection (B) of the variable resistance (T2) and the output of the transducer (1) and/or the measuring winding (3).

9. A device for measurement of angular velocity of a rotating body substantially as herein described with reference to and as illustrated in the accompanying drawings.

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